# Real-time teamwork evaluation and C2 crisis management: overview of doctoral research

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**Abstract.** Evaluation of human performance and cognition has been around for decades. But the growing number of teamwork situations and the growing complexity of military operations and context of command and control of operations have made real time evaluation of team cognition a real need for tomorrow technologies and tools. Being able to assess in real time the individuals and team cognition and state would allow for the development of adaptive tools and systems, gaining in efficiency and performance and lowering errors rate. Our objective is to find appropriate metrics that would allow for such an assessment, in the very constraining context of Current Ops of Air Command and Control rooms, requiring no instrumentation of the monitored operators.

## Introduction

Modern military operations context has changed a lot in the past decades. Conflicts and operations keep getting more complex. The need for a better shared understanding of crisis dynamics is urgent. In the same time, we are facing the multiplication of information sources. The internet of things, social media, drones, etc. can give precious insights, helping create the global crisis dynamics picture needed today. Unfortunately, such an amount of data is overwhelming human operators, threatening to lower the performance instead of improving it.

Artificial Intelligence tools, as well as big data, analytics and cognitive computing will help making sense and extracting valuable intels from those data. In order to be efficient they have to be integrated not as simple tools but as coworkers who thus augment humans by creating a man-machine team. Cognitive assistants (Desclaux et al., 2016), real-time adaptive tools and AI decision support systems involves not only being able to make sense of the data of the situation but also knowing about the state, needs and intentions of the operators and the team.

### Collaboration, C2 and team cognition

Teamwork performance and collaboration is key for modern organizations in charge of civilian or military security tasks. The command and control (C2) domain (military or civil), due to its time-sensitive and collaborative nature, is often used to study collaboration and team cognition. In 2014 HFM-156 working group from NATO Science & Technology Office (STO) published a detailed study on current C2 measurement methods (Berggren, Kermarrec, Banko, Wikberg, & Oleksandur, 2014). From this study stands out the need for developing real-time assessment methods linked to non-invasive psychophysiological methods in ecological environment. These methods, associated with AI tools, would allow increasing real-time agility and efficiency.

## Hypothesis and research questions

When studying team cognition measurement methods, we quickly find that they statistically cluster into 4 meaningful concepts (Berggren, Prytz, Johansson, & Nahlinder, 2011). Workload, teamwork, situation awareness and performance are interconnected and affect one another. According to Berggren, we can formulate our hypothesis in the following way: *The performance of a group can be predicted by a real time evaluation of the workload, situation awareness and teamwork of its members by monitoring them*.

Workload, and more specifically Cognitive workload, and Situation Awareness (SA), are core concepts in human factors and more generally when it comes to assessing human performance and cognition.

Cognitive Workload, refers to the mental effort required by an individual to complete a task, or more simply, the amount of work that an individual can perform at a certain time.

Situation awareness (SA) refers to the understanding an individual builds of the current environment and its surroundings, including a prediction of its future states based on the knowledge of past ones. To sum-up, it is knowing what is going on, and project what may happen (Endsley, 1995). In a team environment, Shared SA (SSA) is the understanding of elements of the situation that two (or more) individuals have to share in order to achieve their interrelated tasks. The

SA concept is central, but due to its subjective and verbal nature, it is not measurable in real-time in an ecological environment. Since Workload, teamwork and SA are linked, evaluating teamwork and workload, which are more easily measurable in real-time, may be a way to detect SA difference between teammates in real-time.

Our goal is to identify metrics that would allow a future system to determine automatically and in real-time if a team is on the same track.
We will address the following research questions:

- Is a difference of understanding of the situation detectable in psychophysiological, behavioral and communication activities of teammates?
- Is the modification of the same metrics of teammates, within a sort timespan, an indicator of shared cognition?

# Work to date

First step has been to identify evaluation methods that would fit with the constraints of C2 ecological context. We looked into human work evaluation methods requiring no equipment of the operator himself that could be done in real-time, without interfering with the task. It also needs metrics and indicators which can be treated automatically.

Identified measurement tools include Eye-tracking, keyboard and mouse activity, and communications recordings.

A first experiment has been conducted late December on students from the Ecole Nationale Superieure de Cognitique. We measured team cognition of 3 teams of 3 individuals playing a command and control game against an AI. Each one of them played 11 games of 20 minutes. We are currently exploiting the data.

In order to validate our hypothesis, we need to:

- Synchronize data sets from every team member.
- Identify key events of the scenarios that affected at least 2 of them
- Identify and compare their reactions to those events in the different metrics
- Look for similarities in metrics modifications in response to a same event.
- Determine combinations of metrics that are statistically the most reliable indicator of the collaboration.

A second experiment with a team of 2 operators with interrelated but different tasks in very controlled scenarios is currently being developed. It is based on DARPA's Warship Commander Task scenarios (St. John, Kobus, Morrison, & Schmorrow, 2004). It will allow us to validate the metrics identified in the first experiment.

# Future steps

Next steps include conducting the second experiment on a larger sample (at least 20 groups of 2). This will be concurrent with an activity analysis on actual C2 operators at Military Air Expertise Center (CEAM - BA 118) and The Air Operations Center of Excellence (CASPOA - Lyon Mt Verdun) to better determine ecological context and constraints. This is important in order to understand how a future monitoring system can be integrated in their work environment in the most efficient way. The system and metrics will then be tested in a large scale exercise in actual C2 context during a real world operation. Two possible exercise have been identified, NATO Trident Juncture exercise and a CASPOA Annual one, both to be held in 2019.

As for future applications, identified metrics if proven successful, will be organized in a Bayesian network allowing to cross metrics to guarantee the result of the measurements. Afterwards, an automated assessment system can be developed or integrated in an already existing cognitive assistant, in order to help detect possible misunderstanding in teams or adapt systems and interfaces in real-time depending on the operator's cognitive state and that of his colleagues.

It is important for us that those results can be transferable to non-military and even non C2 situations. Every sociotechnical systems where team cognition and SA are keys to team performance can benefit from this work.

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